(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 June 2003 (26.06.2003)

PCT

(10) International Publication Number
WO 03/051531 A1

(51) International Patent Classification[7]: B06B 3/00

(21) International Application Number: PCT/GB02/05700

(22) International Filing Date:
16 December 2002 (16.12.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0130129.0 17 December 2001 (17.12.2001) GB

(71) Applicant *(for all designated States except US)*: **SONICO LIMITED** [GB/GB]; Purac House, Birmingham Road, Kidderminster DY10 2SH (GB).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **AMATO, Tony** [GB/GB]; Sonico Limited, Purac House, Birmingham Road, Kidderminster DY10 2SH (GB).

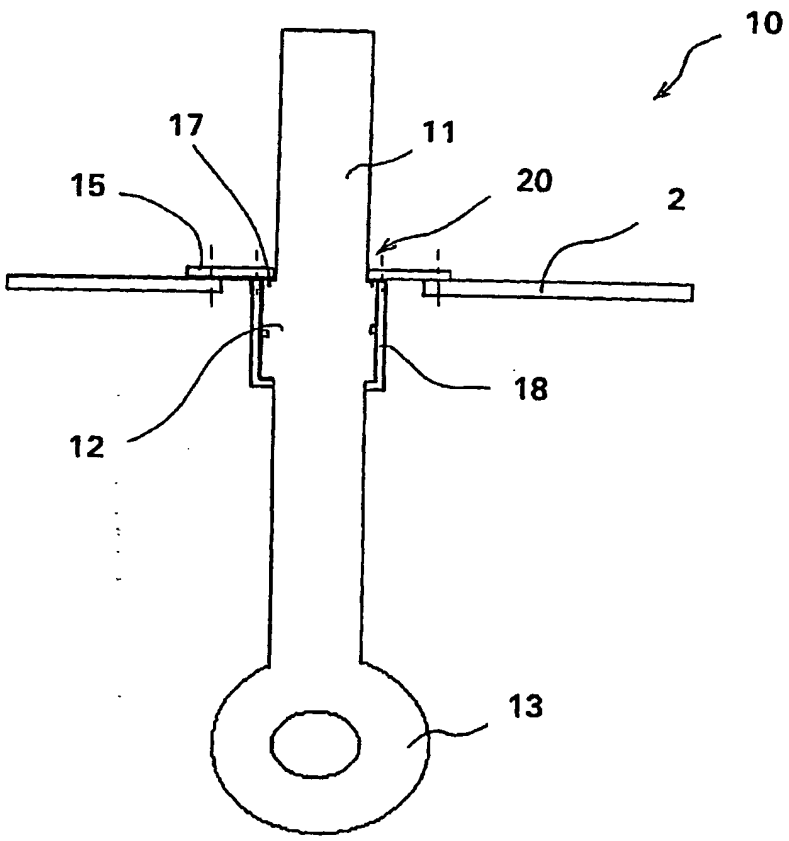
(74) Agents: **SUÈR, Steven, Johannes** et al.; Ablett & Stebbing, Caparo House, 101-103 Baker Street, London W1U 6FQ (GB).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE,

[Continued on next page]

(54) Title: APPARATUS FOR GENERATING ULTRASOUND



(57) Abstract: The present invention relates to ultrasound generating apparatus, the apparatus comprising an ultrasonic stack (20) having a transducer (11) for generating ultrasound, a booster (12) for amplifying vibrational energy generated by the transducer and a mounting plate (15) for mounting the stack to a vessel, wherein the booster is provided on an inwardly orientated face of the mounting plate in relation to the vessel.

WO 03/051531 A1

ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

APPARATUS FOR GENERATING ULTRASOUND

The present invention provides apparatus for generating ultrasound.

The term "ultrasound" is commonly used to refer to sound energy having a frequency above 20 kHz, i.e. frequencies higher than those normally audible to humans. Ultrasound is conventionally generated by a transducer, which converts mechanical or electrical energy into ultrasonic vibrations, and transmitted to the desired medium, typically via a horn or probe. Most conventional ultrasonic transducers are designed to deliver frequencies in the range from 20 to 35 kHz. Transducers operating below 20 kHz can be excessively noisy, whereas reductions in power delivery can occur above 35 kHz.

The industrial uses of ultrasound are varied and well known, for example, welding, cutting, atomisation, cleaning and decontamination, and industrial processing.

As referred to above, apparatus for generating ultrasound typically comprises a transducer and a horn or probe. Additional components commonly referred to as boosters and extenders are often used with the transducer and horn or probe. The booster and/or extender are typically used to modulate the amplification of ultrasonic vibration at the face of the horn or probe, e.g. the booster and/or extender may be used to increase or decrease the vibrational energy emitted at the face of the horn or probe. The term "ultrasonic stack" is conventionally used in the art to describe apparatus for generating ultrasound which comprises a transducer, booster, extender, and horn or probe combination. The transducer passes

vibrations through the booster and/or extender to the horn or probe, and thus into the desired medium. Thus, in operation the entire stack vibrates apart from those points which are at a nodal position in the ultrasonic vibration wavelength. The wavelength will be determined by the frequency of vibration of the transducer.

Ultrasonic stacks are usually designed so that the booster is at a nodal point in the stack. Thus, whilst some parts of the booster will vibrate, there will be a part of the booster which is substantially static.

Securing an ultrasonic stack into an industrial application can thus create difficulties. The nodal point of vibration of the stack is small, and ensuring that a vibrating stack is securely attached to, for example, a vessel, a pipe or flow cell having high pressure fluid passing therethrough is difficult.

In this regard, boosters are conventionally top mounted and sealed with flat gaskets. As shown in Figure 1, such a stack 1 conventionally comprises a booster 5 mounted to a shaft 3 of, for example, a radial horn 4. The connection may be made using, for example, a threaded stud 8, and/or may include welding the two components together. In order to allow insertion and removal of the stack 1 from a housing 2, an aperture 7 of suitable dimensions is provided. In order to secure the stack to the housing, a top plate 6 is provided around the shaft 3. The top plate is sealably connected to the booster 5 and the top plate is in turn sealably connected to the housing 2 adjacent the periphery of the aperture 7.

The relative dimensions of the radial horn 4, the shaft 3 and the booster 5 mean that the booster 5 and the radial horn 4 are separate elements which are connected once the top plate 6 has been placed on the shaft, in effect between the larger dimensioned booster and the end of the radial horn.

The discrete nature of the radial horn and the booster has certain disadvantages, particularly in that the inherent vibration associated with the stack inevitably undermines the connection between these components. Hence the connection between the radial horn and the booster is often prematurely compromised after time through usage of the stack.

Further, with the arrangement described above, constraints are placed on the nature of the connection between the stack and the housing.

An object of the present invention is to an arrangement which seeks to alleviate such problems associated with known arrangements.

According to an aspect of the present invention there is provided ultrasound generating apparatus; the apparatus comprising:-

an ultrasonic stack having a transducer for generating ultrasound and a booster for amplifying vibrational energy generated by the transducer;

a mounting plate for mounting the stack to a vessel; wherein the booster is provided on an inwardly orientated face of the mounting plate in relation to the vessel. In this way, the booster projects into the interior of the vessel.

Preferably, the stack comprises a substantially longitudinal

element, the booster comprising an enlarged or sleeve-like portion on said longitudinal element. In preferred embodiments, the transducer comprises a shaft of substantially circular cross-section, the booster comprising a longitudinal portion of increased radius provided on the shaft.

The booster may present at one end a sealing surface for contact with the mounting plate. This preferably comprises a substantially annular surface, having therein an annular channel. In preferred embodiments, a seal is provided within the annular channel. Using a channel arrangement for housing the seal allows the positional accuracy of the seal to be maintained when compared with a flat seal.

Conveniently, the seal is an o-ring seal. The o-ring seal is formed of a low-shrinkage elastomer. It is moulded for high dimensional accuracy. The seal is dimensioned such that when the booster sealing surface is urged into contact with the mounting plate it is placed under an internal compressive pressure. It is thereby forced to deform and is hence pre-loaded to an extent which will exceed any system pressures experienced by the seal between the booster and the mounting plate in use. As such, the seal is intact to 100 Bar affording the apparatus a design value of 10 for its "factor of safety".

Preferably, the booster is held into contact with the mounting plate by way of one or more clamps which contact an annular surface provided on the booster at its end opposite from the sealing surface end which contacts the mounting plate.

In preferred embodiments, two clamps are provided, each being half of a flanged collar.

Conveniently, the clamps are bolted to the mounting plate. Preferably, the ultrasonic stack has a radial horn at one end.

In preferred embodiments, the ultrasonic stack comprises a transducer, a booster and a radial horn/probe, all formed as an integral unit. This enhances the durability of the apparatus.

According to a further aspect of the present invention there is provided ultrasonic stack apparatus; the apparatus comprising:-

an ultrasonic stack having a transducer for generating ultrasound and a booster for amplifying vibrational energy generated by the transducer;

a mounting plate for mounting the stack to a vessel; wherein the mounting plate is coupled to the stack so as to project the booster into the interior of the vessel.

An example of the present invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 shows a conventional ultrasonic stack mounting arrangement;

Figure 2 shows an ultrasonic stack mounting apparatus of the present invention; and

Figure 3 shows a exploded perspective view of certain components the ultrasonic stack arrangement of Figure 2.

Figure 1 is discussed above in the introduction. Turning to Figures 2 and 3, there is shown an ultrasonic stack apparatus 10 of the present invention.

In this respect, the apparatus comprises a stack 20 formed from a transducer 11, a booster 12 and a radial horn 13. The transducer, booster and radial horn are formed integrally as a one piece member.

The stack takes the form of a substantially longitudinal shaft of circular cross-section, the booster comprising an enlarged portion on said longitudinal element.

The booster presents at one end a sealing surface 14 for contact with a mounting plate (or so-called top plate 15).

This booster sealing surface 14 comprises a substantially annular track, having therein an annular channel 16.

Mounted in the channel is a seal in the form of an o-ring seal 17. The o-ring seal is moulded from a low-shrinkage elastomer. It is moulded for high dimensional accuracy and is dimensioned such that when the booster sealing surface 14 is urged into contact with the mounting plate 15, it is placed under an internal compressive pressure. It is thereby forced to deform and is hence pre-loaded to an extent which is set to exceed any system pressures experienced by the seal in use.

By way of the annular channel and o-ring seal, the positional accuracy of the seal can be maintained. As such the seal can be more reliably formed and maintained.

The seal between the booster sealing surface 14 and the mounting plate has three sections, namely a metal to metal seal at the inner and outer peripheries of the radial extent of the booster sealing surface 14, and a elastomer to metal seal sandwiched therebetween. The elastomer to metal seal

takes up around a third of the radial extent of the seal, each of the metal to metal seals also taking up a third respectively.

As such, the seal can be made to be intact to system pressures of 100 Bar, affording the apparatus a design value of 10 for its "factor of safety".

The booster 12 is held into contact with the mounting plate 15 by way of clamps 18 which contact an annular surface 19 provided on the booster at its lower end, opposite from the sealing surface end which contacts the mounting plate.

These clamps 18 each take the form of half of a flanged collar (or a split flange collar). The clamps are connected to the mounting plate using bolts 19.

It will be understood that having the booster in the underslung position whereby it is submerged within the vessel interior, affords certain advantages. It more readily allows the stack to be provided as a single integral unit, as the mounting plate does not need to be provided between the booster and the radial horn.

Further, the positioning of the stack is enhanced in relation to ensuring that the nodal point where there is least vibration of the stack, is as close as possible to the point of sealing and mounting with the vessel housing.

Claims

1. Ultrasound generating apparatus; the apparatus comprising:-

an ultrasonic stack having a transducer for generating ultrasound and a booster for amplifying vibrational energy generated by the transducer;

a mounting plate for mounting the stack to a vessel; wherein the booster is provided on an inwardly orientated face of the mounting plate in relation to the vessel.

2. Ultrasound generating apparatus according to claim 1, wherein, the stack comprises a substantially longitudinal transducer element, the booster comprising an enlarged portion on said longitudinal element.

3. Ultrasound generating apparatus according to claim 1 or 2, wherein the transducer comprises a shaft of substantially circular cross-section, the booster comprising a longitudinal portion of increased radius provided on the shaft.

4. Ultrasound generating apparatus according to any one of claims 1 to 3, wherein the booster presents at one end a sealing surface for contact with the mounting plate.

5. Ultrasound generating apparatus according to any preceding claim, wherein the booster sealing surface comprises a substantially annular track, having therein an annular channel.

6. Ultrasound generating apparatus according to any preceding claim, wherein a seal is provided within the annular

channel.

7. Ultrasound generating apparatus according to claim 6, wherein the seal is an o-ring seal.

8. Ultrasound generating apparatus according to claim 7, wherein the o-ring seal is formed of a low-shrinkage elastomer.

9. Ultrasound generating apparatus according to any preceding claim, wherein the booster is held into contact with the mounting plate by way of one or more clamps which contact an annular surface provided on the booster at its end opposite from the sealing surface end which contacts the mounting plate.

10. Ultrasound generating apparatus according to claim 9, wherein two clamps are provided, each being half of a flanged collar.

11. Ultrasound generating apparatus according to claim 9 or 10, wherein the clamps are bolted to the mounting plate.

12. Ultrasound generating apparatus according to any preceding claim, wherein the ultrasonic stack has a radial horn at one end.

13. Ultrasound generating apparatus according to any preceding claim, comprising a transducer, a booster and a radial horn/probe all provided as an integral unit.

14. Ultrasonic stack apparatus; the apparatus comprising:-
an ultrasonic stack having a transducer for generating

ultrasound and a booster for amplifying vibrational energy generated by the transducer;

a mounting plate for mounting the stack to a vessel; wherein the mounting plate is coupled to the stack so as to project the booster into the interior of the vessel.

15. Ultrasound generating apparatus substantially as hereinbefore described with reference to Figures 2 and 3 of the accompanying drawings.

16. Ultrasonic stack apparatus substantially as hereinbefore described with reference to Figures 2 and 3 of the accompanying drawings.

[PRIOR ART]

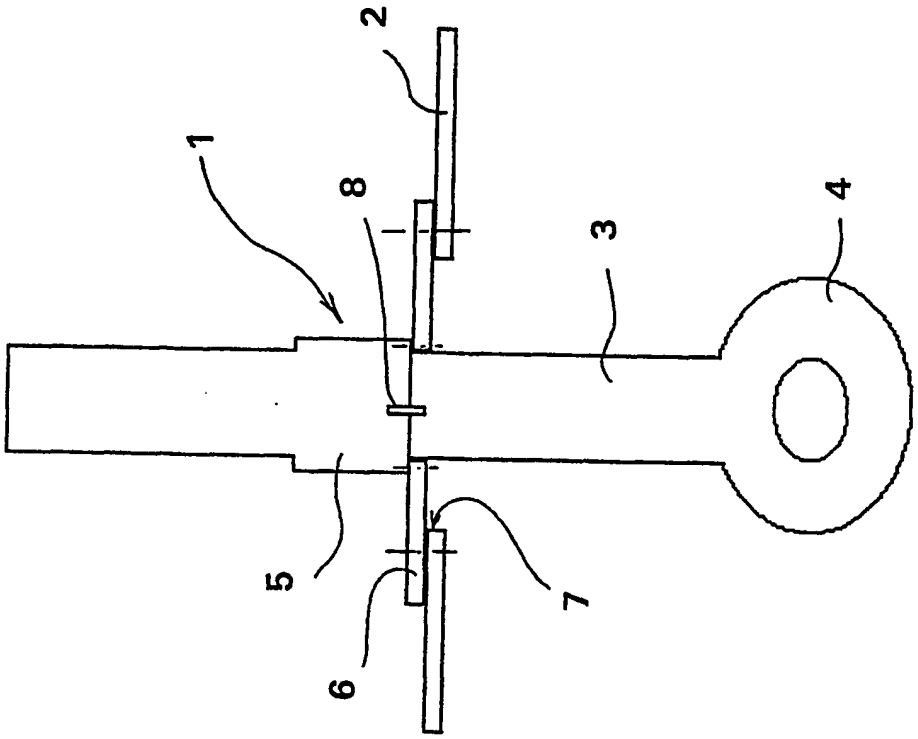


Figure 1

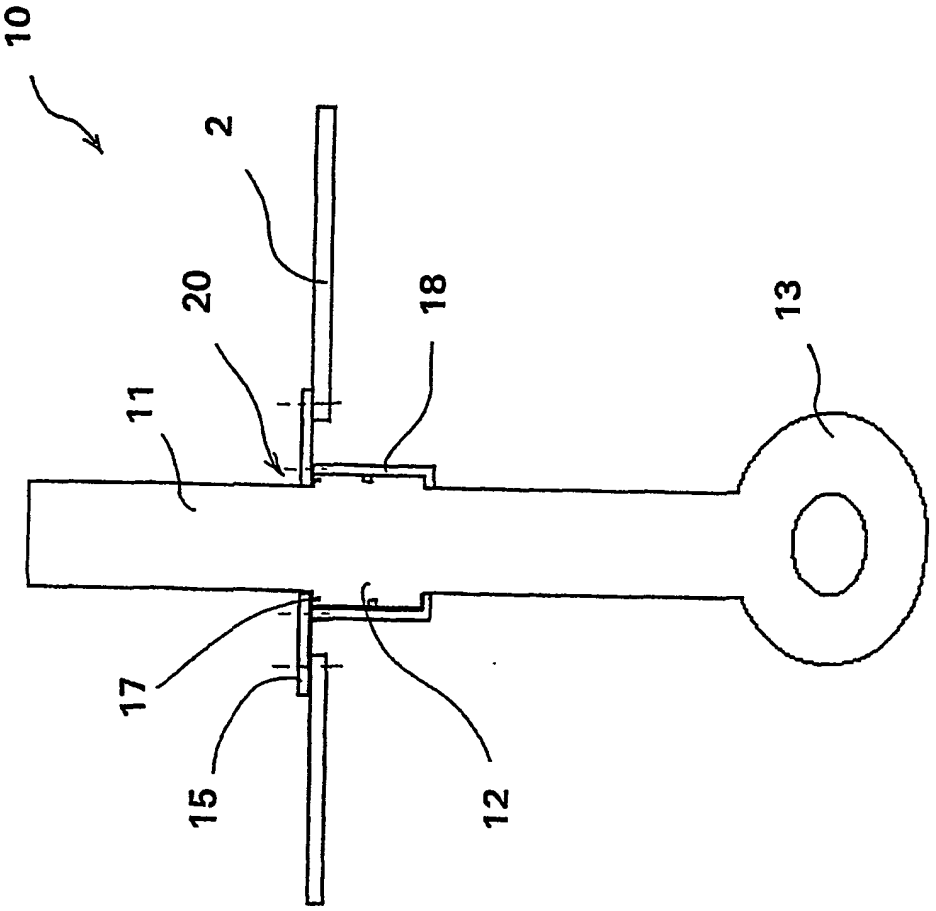


Figure 2

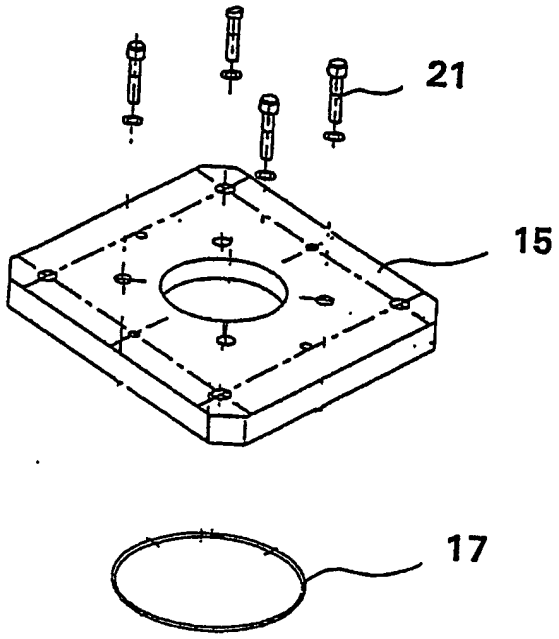
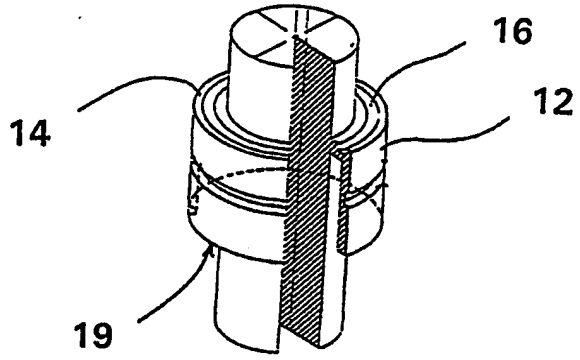
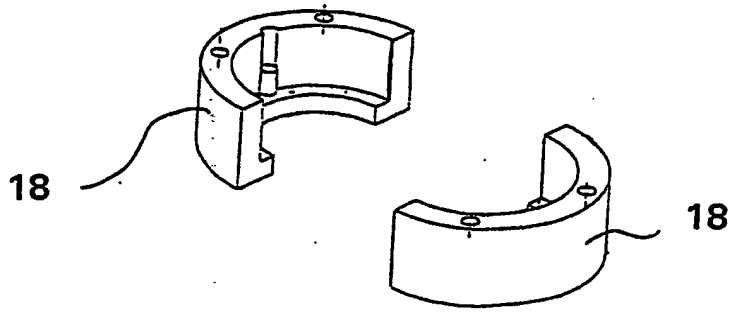


Figure 3





INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/GB 02/05700

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B06B3/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B06B G10K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 647 336 A (COENEN JOSEPH D ET AL) 3 March 1987 (1987-03-03) column 4, line 53 -column 5, line 38; figure 4	2,3,9, 11,13
A	US 4 870 743 A (GILMORE JAMES R) 3 October 1989 (1989-10-03) column 3, line 1 - line 19	1-9,11, 13-16
A	US 5 590 866 A (CUNNINGHAM PATRICK M) 7 January 1997 (1997-01-07) column 3, line 59 -column 4, line 64	1-4, 6-10, 13-16
A	US 4 074 152 A (ASAI KIYOKAZU ET AL) 14 February 1978 (1978-02-14) figure 5	1,12

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 April 2003	17/04/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Swartjes, H

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intel ›nal Application No
PCT/GB 02/05700

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 4647336	A	03-03-1987	CA	1277301 A1	04-12-1990
US 4870743	A	03-10-1989	NONE		
US 5590866	A	07-01-1997	US	5443240 A	22-08-1995
			CA	2130209 A1	10-08-1995
			DE	69515921 D1	04-05-2000
			DE	69515921 T2	26-10-2000
			EP	0667189 A2	16-08-1995
			JP	7213998 A	15-08-1995
US 4074152	A	14-02-1978	JP	51078317 A	07-07-1976
			JP	57007791 B	12-02-1982
			JP	1114371 C	29-09-1982
			JP	52026213 A	26-02-1977
			JP	57007792 B	12-02-1982
			JP	51040090 A	03-04-1976